HR-393 Preventing Cracking at Diaphragm/Plate Girder Connections in Steel Bridges

Key Words: Bridge maintenance, welded plate girder bridges, repair, web cracking, web gap

Abstract:

Some of the Iowa Department of Transportation (Iowa DOT) continuous, steel, welded plate girder bridges have developed web cracking in the negative moment regions at the diaphragm connection plates. The cracks are due to out-of-plane bending of the web near the top flange of the girder. The out-of-plane bending occurs in the "web-gap," which is the portion of the girder web between (1) the top of the fillet welds attaching the diaphragm connection plate to the web and (2) the fillet welds attaching the flange to the web. A literature search indicated that four retrofit techniques have been suggested by other researchers to prevent or control this type of cracking: (1) drilling holes at crack tip locations, (2) increasing the web gap length, (3) providing rigid attachment between the connection plate and the tension flange, and (4) removing the diaphragms.

To eliminate the problem in new bridges, current AASHTO Specifications require a positive attachment between the connection plate and the top (tension) flange. Applying this requirement to existing bridges is expensive and difficult. The Iowa DOT has relied primarily on the hole-drilling technique to prevent crack extension once cracking has occurred; however, the literature indicates that hole-drilling alone may not be entirely effective in preventing crack extension.

The objective of this research was to investigate experimentally a method proposed by the Iowa DOT to prevent cracking at the diaphragm/plate girder connection in steel bridges with X-type or K-type diaphragms. The method consists of loosening the bolts at some connections between the diaphragm diagonals and the connection plates.

The experimental investigation of the method included selecting and testing five bridges: three with X-type diaphragms and two with K-type diaphragms. During 1996 and 1997, these bridges were instrumented using strain gages and displacement transducers to obtain the response at various locations (web gaps, diaphragm elements, and girder flanges and webs) before and after implementing the method. Bridges were subjected to loaded test trucks traveling in different lanes with speeds varying from crawl speed to 65 mph (104 km/h) to determine the effectiveness of the proposed method.

The results of the study show that the effect of out-of-plane loading was confined to widths of approximately 4 inches (100 mm) on either side of the connection plates. Further, they demonstrate that the stresses in gaps with drilled holes were higher than those in gaps without cracks, implying that the drilling hole technique is not sufficient to prevent crack extension. The behavior of the web gaps in X-type diaphragm bridges was greatly enhanced by the proposed method as the stress range and out-of-plane distortion were reduced by at least 42% at the exterior girders. For bridges with K-type diaphragms, a similar trend was obtained. However, the stress range increased in one of the web gaps after implementing the proposed method. Other design aspects (wind, stability of compression flange, and lateral distribution of loads) must be

considered when deciding whether to adopt the proposed method.

Considering the results of this investigation, the proposed method can be implemented for X-type diaphragm bridges. Further research is recommended for K-type diaphragm bridges.